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REVIEWS.

THE DEVELOPMENT OF CHLOEÖN (*Ephemera*) DIMIDIATUM. By *Sir John Lubbock.* Parts I. II. From the Transactions of the Linnæan Society, London. Vol. XXV. 4to, 1866.

One of the most interesting discoveries in entomology is the fact that the May-fly, or Shad-fly, during its development from the time of leaving the egg up to maturity, moults its skin nineteen times before leaving the water, and once afterwards on arriving at the winged state.

All the books teach that there are three distinct states of the insect's life after hatching from the egg, namely, the larva, pupa, and imago; but there are many species belonging to different suborders of the six-footed insects, in which these stages graduate almost insensibly into each other. The terms larva and pupa are but relative, and not fixed and absolute. In the beetle or butterfly, the grub or caterpillar certainly seems very distinct from the chrysalis. But we have in the collection of the Essex Institute a series illustrating the transformations of the caterpillar into the pupa or chrysalis, which show several successive changes of form most remarkable and interesting to the student. There is also a gradual change of form from the pupa to the imago or perfect state, which most observers have not noticed.

The writer has shown* that the Humble-bee, before reaching the winged state, moults at least ten times, and probably a greater number. The bee-state is reached by a very gradual change of form. The newly hatched larva differs but slightly in appearance from the mature embryo just before hatching. The worm-like larva merges gradually into the pupa. Scarcely does the larva stop eating and gain its full size, when, on removing the loosening skin, the tegument of the half-formed pupa can be detected beneath, with the rudiments of the mouth-parts, antennæ, and wings, together with the ovipositor, which have begun to assume the shape of the same parts in the mature bee. They are, however, rudely shaped and but partially formed. So also the pupa merges into the bee state by insensible gradations, so that it is almost impossible to say absolutely which is pupa and which imago, from the inspection of specimens before us. Thus metamorphosis is but a growth and evolution of parts, intensified, so to speak, at certain intervals to adapt it to certain modes or conditions of life. In those insects which are active in the preparatory stages, and have the same habits in maturity as in the larva and pupa stage, such as the grasshopper and its allies, the changes are slow, and the metamorphosis slightly marked. In the butterfly and bee, however, whose life is so distinct in the perfect state, from the caterpillar or grub, the changes are rapid, though gradual, and strongly marked. They are not perhaps due so much to immediate physical agencies, as to the plan of life originally marked out for the insect by the creative mind.

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*Observations on the Development and Position of the Hymenoptera, with notes on the Morphology of Insects. By A. S. Packard, jr. From the Proceedings of the Boston Society of Natural History. 1867, 8vo.

In the present state of science we would prefer to think that structure is *correlated* to the mode of life, rather than that it is dependent on physical agencies. We feel scarcely prepared to believe with our author that the "actual form" of the caterpillar "is mainly due to the influence of the conditions in which it lives."*

We must look deeper than the agency of physical causes in the production of the various forms of life. In endeavoring to solve the problem of life and its manifestations, man may advance in knowledge without actually grasping the truth.

The theories now in vogue, suggested by Lamarck or Darwin, or as modified by other naturalists, though so stimulating to scientific thought, are yet not satisfactory, and do not go to the bottom of the matter. We must still wait patiently, and meanwhile observe, experiment, and reflect, and thus continue to question nature until she yields a willing reply.

We extract the following interesting remarks on the metamorphoses of insects, with the author's general conclusions:—

> The larvæ of insects are generally regarded as being nothing more than immature states, as stages in the development of the egg into the imago; and this might more especially appear to be the case with those insects in which the larvæ offer a general resemblance in form and structure (excepting of course so far as relates to the wings) to the perfect insects. Nevertheless, we see that this would be a very incomplete view of the case. The larva and pupa undergo changes which have no relation to the form which they will ultimately assume. With a general tendency, as regards size and the production of wings, to this goal, there are combined other changes bearing reference only to their existing wants and condition.
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> Nor is there in this, I think, anything which need surprise us. External circumstances act on the insect in its preparatory states as well as in its perfect condition. Those who believe that animals are susceptible of great, though gradual, change through the influence of external conditions, whether acting, as Mr. Darwin has suggested, through natural selection, or in any other manner, will see no reason why these changes should be confined to the mature animal. And it is evident that creatures which, like the majority of insects, live during different periods of their existence in very different circumstances, may undergo considerable changes in their larval organization, in consequence of forces acting on their larval condition, not, indeed, without affecting, but certainly without affecting, to any corresponding extent, their ultimate form.
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> We may now pass to the second part of the subject,—that is to say, the apparently sud-

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* "The caterpillar owes its difference from the butterfly to the early stage at which it leaves the egg; but its actual form is mainly due to the influence of the condition in which it lives." Part II. p. 112.

den and abrupt nature of the changes which insects undergo. I say "apparently," because the changes in the internal organs, though rapid, are in reality gradual; and even as regards the external form, though the metamorphosis may take only a few minutes, this is but the change of outer skin — the drawing away, as it were, of the curtain; and the new form which then appears has been in preparation for days or, perhaps, weeks before.

Swammerdam, indeed, supposed (and his view was adopted by Kirby and Spence) that the larva contained within itself "the germ of the future butterfly, enclosed in what will be the case of the pupa, which is itself included in the three or more skins, one over the other, that will successively cover the larva." This is entirely a mistake; but it *is* true that, if you examine a larva shortly before it becomes a pupa, you will find that the skin is loose, and that within it the future pupa may be traced. In the same manner, if you examine a pupa which is about to disclose the butterfly, you will find the future insect, soft indeed and imperfect, but still easily recognizable, lying more or less loosely within the pupa-skin. More than one such inner skin, however, is never present.

One fundamental difference between an insect and a vertebrate animal is, that whereas in the latter, as for instance in ourselves, the muscles are attached to an internal bony skeleton, in insects no such skeleton exists. They have no bones, and their muscles are attached to the skin. Hence the necessity for the hard and horny dermal investment of insects, so different from the softness and suppleness of our own skin.

Moreover the result is, that without a change of skin a change of form is impossible. The chitine, or horny substance, forming the outside of an insect, is formed by a layer of cells lying beneath it, and, once formed, cannot be altered. From this it follows, that every change of form is necessarily accompanied by a change of skin.

In some cases, as for instance in *Chloeon*, each change of skin is accompanied by a small change of form, and thus the perfect insect is more or less gradually evolved. In others, as for instance in Caterpillars, several changes of skin take place without any alteration of form, and the change, instead of being spread over many, is confined to the last two moults.

Very little consideration will afford us an explanation of this difference. The mouth of the Caterpillar is provided with a pair of strong jaws, fitted to eat leaves; and the digestive organs are adapted for this kind of food.

On the contrary, the mouth of the butterfly is suctorial; it has a long proboscis, beautifully adapted to suck the nectar from flowers, but which would be quite useless, and, indeed, only an embarrassment to the larva. The digestive organs also are adapted for the assimilation, not of leaves, but of honey. Now it is evident that if the mouth-parts of the larva were gradually metamorphosed into those of the perfect insect, through a number of small changes, the insect would in the mean time be unable to feed, and liable to perish of starvation in the midst of plenty.

On the contrary, in the Orthoptera, and, as a general rule, among those insects in which the changes are gradual, the mouth of the so-called larva resembles that of the perfect insect, and the principal difference is in the presence of wings.

Similar considerations throw much light on the nature of the chrysalis or pupa state — that remarkable period of death-like quiescence which is one of the most striking characteristics of insect-metamorphosis. The comparative quiescence of the pupa is mainly owing to the rapidity of the changes going on in it.

In the chrysalis of a butterfly, for instance, not only, as has been already mentioned, are the mouth and digestive organs undergoing change, but the same is the case with the muscles. The powerful ones which move the wings are in process of formation; and even if they were in a condition favourable to motion, still the nervous system, by which the movements are set on foot and regulated, is also in a state of such rapid change that it could scarcely act.

The conclusions, then, which I think we may draw from the preceding and other considerations, are: —

1st. That the occurrence of metamorphoses arises from the immaturity of the condition in which some animals quit the egg.

2nd. That the form of the larva in insects, whenever it departs from the original vermiform type, depends in great measure on the conditions in which it lives. The external forces acting upon it are different from those which affect the mature form; and thus changes are produced in the young which have reference to its immediate wants, rather than to its final form.

3rd. That metamorphoses may therefore be divided into two kinds, developmental and adaptational.

4th. The apparent abruptness of the changes which insects undergo arises in great measure from the hardness of their skin, which permits no gradual alteration of form, and which is itself necessary in order to afford sufficient support to the muscles.

5th. The immobility of the pupa or chrysalis depends on the rapidity of the changes going on in it.

6th. Although the majority of insects go through three well-marked stages after leaving the egg, still a large number arrive at maturity through a somewhat indefinite number of slight changes.

7th. When the external organs arrive at this final form before the organs of reproduction are matured, these changes are known as metamorphoses; when, on the contrary, the organs of reproduction are functionally perfect before the external organs, or when the creature has the power of budding, then the phenomenon is known as alternation of generations.

Insects present every gradation, from simple growth to alternation of generations.

8th. Thus, then, it appears probable that this remarkable phenomenon may have arisen from the simple circumstance that certain animals leave the egg at a very early stage of development, and that the external forces acting on the young are different from those which affect the mature form.

9th. The dimorphism thus produced differs in many important respects from the dimorphism of the mature form which we find, for instance, in ants and bees; it would therefore be convenient to distinguish it by a different name; and I have ventured to suggest the terms Dieidism and Polyeidism.

The same considerations explain the remarkable fact that in alternation of generations the reproduction is agamic in the one form. This is because impregnation requires the perfection both of external and internal organs; and if the phenomenon arises, as has just been suggested, from the fact that the internal organs arrive at maturity before the external ones, impregnation cannot take place, and reproduction will only result in those species which have the power of agamic multiplication.

REVISION OF THE FOSSIL HYMENOPTERA OF NORTH AMERICA. *I. Crabronidæ and Nyssonidæ.* By *A. S. Packard, Jr., M. D.* From the Proceedings of the Entomological Society. Philadelphia, 1866-67. pp. 167. 8vo.

This work treats of the classification of a large group of the fossorial or digging wasps. It contains descriptions of nearly all the genera and species known to inhabit North America. The species, as well as the genera of the digging wasps, are difficult to identify; but with the detailed descriptions of the genera here given, and the synoptical table of the species, the work of identification has been rendered comparatively easy. The names of species not seen by the author are added, so that it gives a complete list of all the known species, which amount to two hundred and seven, comprised in twenty-five genera, of which one new genus and fifty-eight new species are described. The family characters are discussed at length, and there are a few introductory pages devoted to the general classification of the group, their zoölogical characters, and geographical distribution.